

The University of Washington
Department of Zoology



Callianassidae from the West Coast of North America

by

BELLE ALICE STEVENS

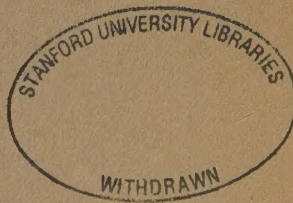
L.C.

A Thesis Submitted in Partial Fulfilment of the Requirements
for the Degree of Doctor of Philosophy

Seattle
University of Washington Press
1928

3781
W31S

UNCLASSIFIED
Dissertation



Callianassidae from the West Coast of North America

BELLE A. STEVENS

University of Washington

Received for publication on August 15, 1928.—Editor.

The present paper is based primarily on a large quantity of material collected by the writer in the region about Friday Harbor, and at Sandy Point on Whidby Island, Washington, during the spring and summer of the years 1924-1928. Considerable material from along the coast of British Columbia, Washington, Oregon and California, transmitted to the writer by various persons who have had opportunity to collect it, has been examined and listed for the particular species concerned. The major part of the work was done at the Puget Sound Biological Station, Friday Harbor, Washington.

Professor Trevor Kincaid of the University of Washington has directed the work in general and has contributed much of the information regarding the economic phase. Several oyster growers have also contributed information regarding the relation to the oyster beds. Dr. T. C. Frye, Director of the Puget Sound Biological Station, and Dr. John E. Guberlet of the University of Washington have given many helpful suggestions. Thruout the progress of the work Dr. Waldo L. Schmitt and Dr. Mary J. Rathbun of the Smithsonian Institution have taken a friendly interest and rendered very definite assistance. Mr. S. N. F. Sanford of the Boston Society of Natural History has made available to the writer information concerned in the Journal of the Boston Society of Natural History. To Hallie R. Donaldson, an art instructor in the Seattle Public Schools, is due appreciation for suggestions and aid in retouching the photographs.

The writer is greatly indebted to Mr. Wayne W. Wells of the Southern Oregon Normal School for much of the material collected in the Friday Harbor region and also that from Coos Bay, Oregon. Dr. C. McLean Fraser of the University of British Columbia very kindly permitted the examination of all Callianassidae material in that institution. The material from California was collected by Mr. G. E. MacGinitie of the State Teachers and Junior College, Fresno, California, in connection with an ecological survey at Elkhorn Bay, Monterey, California. The writer wishes to express especial appre-

ciation to these and to the many other individuals and to the classes at the Puget Sound Biological Station who have made possible the collection of so much very inaccessible material, for practically all collection of Callianassidae requires more or less strenuous digging in order to unearth them from their subterranean habitat.

The classification adopted thru the genera is that of Borradaile (Ann. Mag. Nat. Hist. (7) 12:534-551, 1903). Because of the relative obscurity of the group a description of the superfamily, Thalassinidea, has been included in the body of this paper. The color notes are based on live animals.

Practically nothing except a few very general observations has been recorded as to the life history. Little success was attained in the several attempts to rear the larvae. The life history is a problem in itself. Specimens of Upogebia taken at Friday Harbor late in December, 1925, were with eggs. Specimens taken at Allyn, February 3, 1925, were also with eggs. Both Upogebia and Callianassa with eggs have been collected at Friday Harbor thruout the summer but the most are found in this condition in April, May, June and early July.

Two of the greatest difficulties met with are the differentiation of the females in *Callianassa gigas* Stimpson from those in *C. Californiensis* Dana, and the variation in the proportions of the large cheliped of *C. gigas*. In an attempt to clarify these points the writer has measured various parts of numerous specimens and at a later date hopes to publish findings from which more definite conclusions may be drawn. It was decided not to delay the present publication.

Order *Decapoda* Latreille

Suborder *Reptantia* Boas

Tribe ANOMURA Milne-Edwards

Superfamily THALASSINIDEA Ortmann

Body somewhat shrimplike, having the cephalothorax compressed, the abdomen large, symmetrical, elongated and sometimes with well developed pleura, and the appendages of the sixth segment usually adapted for swimming. The carapace and the covering of the abdomen are often more or less membranous. Second to fourth pairs of legs with last joint not curved and flattened. No pleurobranch to the last leg. No transverse suture on telson.

The Thalassinidea are a group of tailed Decapods which resemble the hermit crabs, Paguridea, in some respects and the lobsters and crawfish, Nephropsidea, in others. They are like the Nephrop-

sidea in the shape of the tail-fan and of the first and often also the second leg. They differ from Nephropsidea, as do also Paguridea, in never having the third leg chelate, often in the reduction of the number of gills and in a tendency of the abdomen to become soft and to lose its pleura. This may be connected with their mode of life which is in most cases a burrowing one. In this they show the same habit of concealment as the Paguridea. They are akin to Paguridea also in the thorn-like shape of the antennal scale in such of them as have it well developed, in the freedom of the last thoracic sternite and in their peculiar way of carrying the last pair of legs rather apart from and above the rest. They differ from the hermit crabs in that these legs are shaped much like the rest, that their second pair of legs is usually chelate, and that their abdomen is symmetrical with a broad tail-fan. A remarkable feature, which recalls the prawns, is the presence in most of them of a special process of the endopodite known as the appendix interna on the abdominal limbs.

The superfamily, Thalassinidea, comprises 4 families of which Axiidae and Callianassidae are represented on the Pacific Coast of North America. The present paper is concerned with the representatives of Callianassidae only.

KEY TO THE FAMILIES OF THE THALASSINIDEA

(The present paper is concerned with Callianassidae only.)

- A. No linea thalassinica; both movable and fixed antennal thorns present, tho sometimes minute (questionably absent in *Scytoleptus*); abdominal pleura large. *Axiidae*
- AA. Linea thalassinica present (except in Callianidea); fixed antennal thorn wanting, scale reduced to a flattened vestige or wanting; abdominal pleura usually small.
 - B. Sutures on both exopodite and endopodite of last limb; abdominal pleura of a good size. *Laomediidae*
 - BB. No sutures on the last limb; abdominal pleura small.
 - C. Second leg chelate or simple; no podobranchs on legs. 3rd-6th abdominal limbs broad; with vestige of antennal scale. *Callianassidae*, p. 318
 - CC. Second leg subchelate; podobranchs on first three legs; abdominal limbs all narrow; without vestige of antennal scale. *Thalassinidae*

Family *Callianassidae* Bate

Body shrimp-like. Rostrum may be either of a good size or small. Linea thalassinica present. Antennal peduncle 5 jointed; antennular flagella short or of moderate length; antennal scale quite vestigial; no antennal thorn. Abdomen extended; abdominal pleura small or absent. Tail-fan well developed and adapted for swimming. First pair of legs unequal or subequal, usually chelate or subchelate but sometimes simple, second pair chelate or simple, third and fourth pairs simple, others variable; legs without podobranchs and usually without mastigobranchs, without pleurobranch. Gills trichobranch or with filaments broadened in various degrees. Third to fifth abdominal limbs with or without appendix interna, their branches broad, and the last pair of limbs without suture on endopodite or exopodite.

Of 13 genera, 2 are represented on the west coast of North America.

KEY TO THE GENERA OF CALLIANASSIDAE FROM THE WEST
COAST OF NORTH AMERICA

- A. Rostrum of good size tho short; first pair of legs alike and subequal. Eye peduncles cylindrical; external maxillipeds pediform. *Upogebia*, p. 318
- AA. Rostrum small, rudimentary or absent; first pair of legs not alike and very unequal; eye peduncles flattened; external maxillipeds operculiform. *Callianassa*, p. 324

Genus *Upogebia* Leach

Rostrum of good size tho short, tridentate, rough and hairy. First pair of legs alike and subequal, with very small pollex, chelate or subchelate; second, third and fourth pairs not chelate, fifth pair usually not chelate. First pair of pleopods different from the following 4 pairs. No appendix interna on abdominal limbs 3-5. Eye peduncles cylindrical, cornea terminal. External maxillipeds pediform.

Upogebia pugettensis (Dana). Figs. 1-5, 20-37.

Gebia pugettensis Dana, Proc. Acad. Sci. Phila. 6:19, 1852; and Crustacea, U.S. Expl. Exped. 1:510, 1852, pl. 32, fig. 1, 1855; Stimpson, Jour. Boston Soc. Nat. Hist. 6:488, pl. 21, fig. 2, 1857; Lockington, Ann. Mag. Nat. Hist. (5), 2:299, 1878.

Gebia californica Stimpson, Proc. Calif. Acad. Sci. 1:88, 1856.

Upogebia pugettensis Holmes, Occas. Papers Calif. Acad. Sci. 7:157, 1900; Rathbun, H. A. E. 10:153, 1904; Schmitt, Univ. of Calif. Pub. in Zool. 23:115, fig. 77, 1921.

Characters. Upper portion of carapace in front of cervical groove flattened, scabrous, hairy and marked with three longitudinal grooves, median groove the shortest; front tridentate, with median



Fig. 1. *Upogebia pugettensis* (Dana) male, dorsal. $\times 1$.

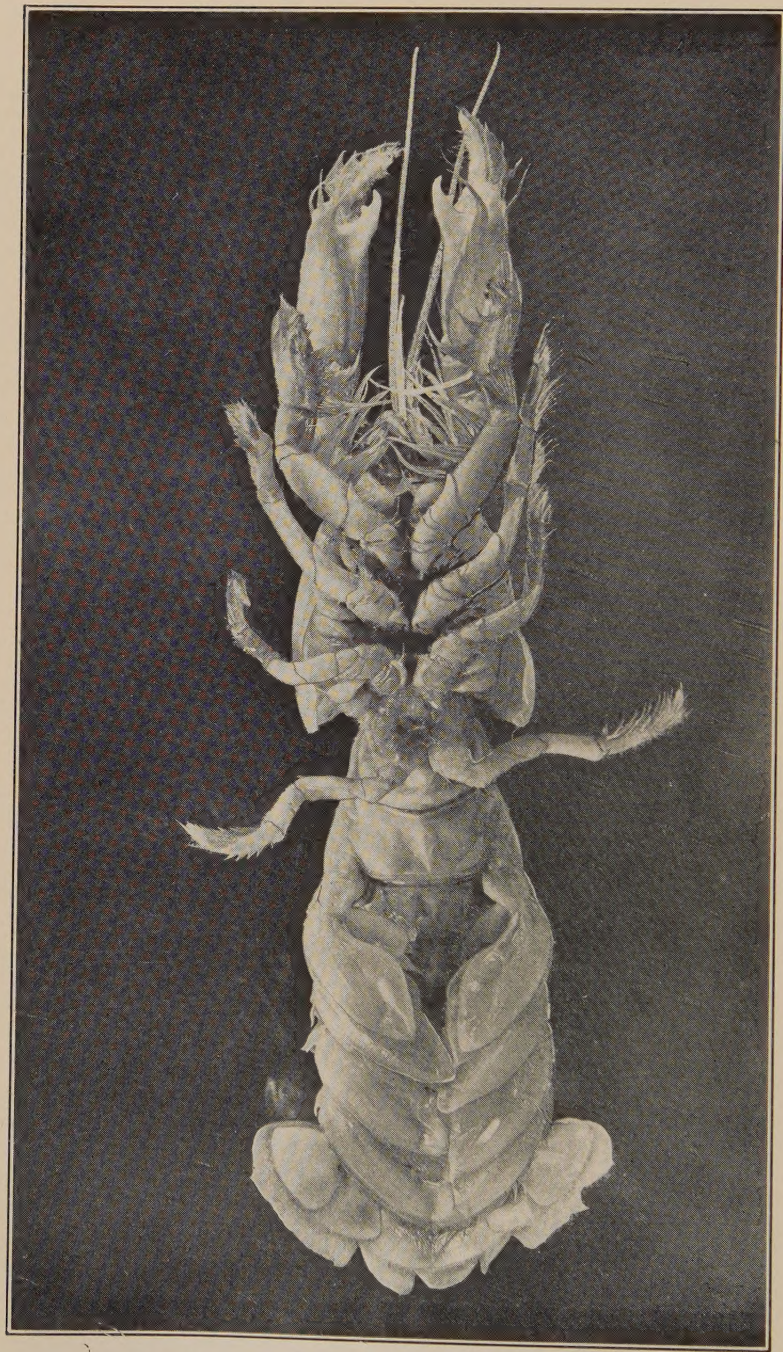


Fig. 2. *Upogebia pugettensis* (Dana) male, ventral. $\times 1$.



Fig. 3. *Upogebia pugettensis* (Dana) female, dorsal. $\times 1$.



Fig. 4. *Upogebia pugettensis* (Dana) female, ventral. $\times 1$.

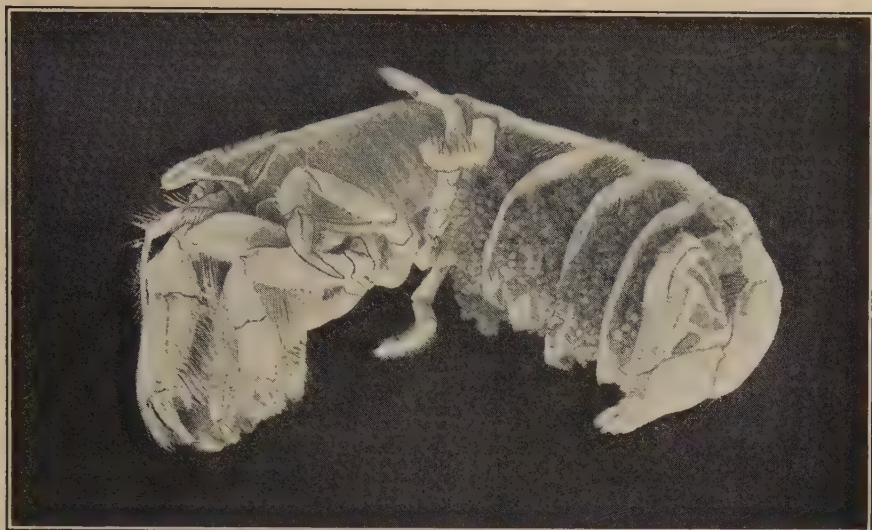


Fig. 5. *Upogebia pugettensis* (Dana) female, with eggs. $\times 1$.

tooth large, horizontal and triangular, lateral teeth short. A minute marginal spine generally present a short distance below the lateral teeth. Eye-stalks short, reaching very little farther forward than lateral teeth of front. Antennule less than half the length of the antenna, flagella subequal. Peduncle of antenna exceeds that of antennule; flagellum ciliate and longer than carapace. Chelipeds equal; merus spinulose and hairy below; carpus with upper and lower edges spinulose and having a spine at the antero-internal angle and another spine a short distance below it; hand with two parallel, scabrous, hairy lines on the upper edge, a transverse granulated line at the proximal end of the inner surface and a line of hairs on the outer surface which is continued obliquely across the carpus; lower side of palm scabrous and hairy; pollex short, bent downward but with the tip turned upward and having a posteriorly directed tooth near middle; dactyl obliquely compressed, incurved, acute, projecting, when closed far beyond the tip of the pollex. Ambulatory legs stout, ciliate; first, second and third somewhat compressed, fourth very little compressed; first and second subequal and longer than the third and fourth which are subequal; first pair considerably longer than the carapace. Uropods short, the inner ramus distally rounded, truncate, the outer rounded. Telson entire, rectangular, wider than long.

Dimensions. Type: length 50.8 mm.

Color. The younger specimens are vinaceous-buff, densely mottled with deep olive to king's blue above, while in the older specimens the

mottling is deep olive; tips of chelipeds and spines light ocraceous-buff; hair muddy tan. In specimens kept in a live box for a few days the deep olive is entirely replaced by king's blue which may appear even on the chelipeds and walking legs.

Type locality. Puget Sound.

Distribution. From Southern Alaska to San Quentin Bay, Lower California (Lockington).

Specimens have been examined by the author from the following locations: *British Columbia*: off Lasqueti Island, at 30-50 meters (tide not known); Locke Bay; Roberts Bay near Sidney, Port Renfrew, Tofino Inlet, Vancouver Island (in the collection at the University of British Columbia); *Washington*: Fossil Bay, Sucia Island; East Sound, Orcas Island; Samish; Blakely Island; Brown Island; beach at Jensen's shipyard a little southeast of Friday Harbor, Minnesota Reef, Argyle, False Bay, Kanaka Bay, Smallpox Bay on San Juan Island; Davis Bay and Flat Point on Lopez Island; Poulsbo; Seabeck; Tracyton; Des Moines; Allyn; Oyster Bay; *Oregon*: Coos Bay.

Localities worthy of note represented in the U.S. National Museum are: *Southeastern Alaska*: Kasaan Bay, Prince of Wales Island; Union Bay, Cleveland Peninsula; Thorn Arm; *British Columbia*: Nanaimo; Comox; Departure Bay; Otter Bay; Pender Island; *Washington*: Sucia Island; *California*: mouth of the Tia Juana River, San Diego County (Rathbun).

Remarks. The tooth of the pollex is sometimes absent, as it was in the specimen described by Dana. "This tooth," says Stimpson, "is a prominent character in all the very numerous specimens in the Smithsonian Museum, but it is obsolete in the specimen described by Dana, altho actual comparison shows them to be the same." In some small specimens from Catalina Island the small marginal spine beneath the lateral teeth of the front was absent, altho they agreed with specimens from northern California in every other essential feature (Holmes).

Genus *Callianassa* Leach

Rostrum short, triangular, rudimentary or absent. First pair of legs dissimilar and very unequal, with well developed chelae; second pair small and chelate, third and fourth pairs simple, fifth pair subchelate. First two pairs of pleopods different from the following three pairs. An appendix interna on abdominal limbs 3-5. Eye-stalks flattened, cornea dorsal and median, small or absent. External maxillipeds operculiform.

KEY TO THE SPECIES OF *CALLIANASSA* FROM THE WEST
COAST OF NORTH AMERICA

- A. Front with median tooth either obscure or not prominent; eyes pigmented.
 - B. Eye-stalks acute, their inner extremities not tuberculiform, divergent or not; cornea at about middle of stalk.
 - C. Hand of first ambulatory leg with pollex about 1.5-2 times as broad at base as dactyl; lobe at infero-proximal angle of merus of large cheliped not covered when carpus is bent at right angles to merus; extremities of eye-stalks divergent. *C. gigas*, p. 325
 - CC. Hand of first ambulatory leg with pollex and dactyl subequal at base or the pollex slightly broader; lobe at infero-proximal angle of merus of large cheliped almost completely covered when carpus is bent at right angles to the merus; extremities of eye-stalks usually divergent. *C. californiensis*, p. 333
 - BB. Eye-stalks with their inner extremities tuberculiform and not divergent; cornea considerably in front of middle of eye-stalk. *C. affinis*, p. 341
- AA. Front with sharp and prominent median tooth; eyes not pigmented. *C. goniophthalma*, p. 342

Callianassa gigas Dana. Figs. 6-9, 14-15, 38-54.

Callianassa gigas Dana, Proc. Acad. Nat. Sci. Phila. 6:19, 1852; Crust. U.S. Expl. Exped. 1:512, 1852, pl. 32, fig. 3, 1855; Stimpson, Jour. Boston Soc. Nat. Hist. 6:489, pl. 21, fig. 3, 1857; Milne-Edwards, A., Nouv. Archiv. Hist. Nat. Paris 6:81, 1870; Lockington, Ann. Nat. Hist. (5), 2:302, 1878; Holmes, Occas. Papers Calif. Acad. Sci. 7:162, 1900; Rathbun, H. A. E. 10:154, 1904; Schmitt, Univ. of Calif. Publ. in Zool. 23:119, fig. 80, 1921.

Callianassa longimana Stimpson, Proc. Boston Soc. Nat. Hist. 6:86, 1857; Jour. Boston Soc. Nat. Hist. 6:490, pl. 21, fig. 5, 1857; Cooper, Rep. Expl. and Sur. to Pacific Ocean 12: book 2, 388, 1860; Bate, in Lord's Nat. in Vancouver's Is. 2:270, 1866; Challenger Reports 24:19, 1888; Milne-Edwards, A., Nouv. Archiv. Hist. Nat. Paris 6:83, 1870; Lockington, Ann. Nat. Hist. (5) 2:302, 1878; Holmes, Occas. Papers Calif. Acad. Sci. 7:161, pl. 2, fig. 28, 1900; Rathbun, H. A. E. 10:154, 1904; Hilton, Jour. Ent. Zool. Pomona Coll. 8:63, fig. 14, 1916; Schmitt, Univ. of Calif. Publ. in Zool. 23:117, fig. 79, 1921.

Characters. Median tooth of front small but subacute, with two small lateral teeth as in *C. californiensis*. Eye-stalks similar to those in preceding species but with sides subparallel to about the middle, beyond which the outer margin turns inward more or less abruptly

and continues in a straight or somewhat incurved line; inner margins of the two approximated from the base to about two-thirds the length where they diverge, each to meet the outer margin of the corresponding stalk forming an acute tip which may be somewhat upturned; pigmented cornea at about the middle or just behind the middle of the stalk. Antennules much as in the preceding species. Antennae about one-half as long as the body. Chelipeds in the adult male very unequal, narrower than in *californiensis*; outer surface smooth and glossy except on ischium, margins more or less ciliate and minutely serrulate or denticulate. Large cheliped (adult male) with ischium of similar shape to that of *californiensis* but with the inner surface granulated and the outer surface more or less scabrous; merus similar to that of *californiensis* but the upper margin is not curved and the lobe at the base is more prominent; carpus about three-fourths as wide as long, little longer than merus, usually subequal to palm (may vary greatly), with outer surface very convex, margins subparallel, ciliate, minutely serrulate, thin but slightly produced, the posterior margin below the articulation of the merus very slightly produced backwards into a broadly and evenly rounded lobe; hand the same width and longer than the carpus, strongly compressed but somewhat convex both above and below; palm longer than broad, usually about as long as carpus, with thin, ciliate, parallel margins; practically no hiatus between fingers when closed; small upturned tooth between bases of fingers; fingers shorter than palm and furnished with tufts of hair; pollex bent upward near the tip, upper surface denticulate; dactyl slightly longer than pollex, hooked at tip; upper and lower margins denticulate, inner surface more or less granulated, in adult individuals the prehensile margins of the fingers may be practically without teeth. Small cheliped (male) resembles that of *californiensis* but the carpus is relatively longer and narrower. Large cheliped in the female scarcely distinguishable from that of the female of *californiensis* except that the lobe at the infero-proximal angle is little more than a sharp spine while in *californiensis* it takes more nearly the form of that in the adult male (young males of both species have a small spine). Small chelipeds (female) are also very similar in the two species but in *gigas* the hand and carpus are often somewhat longer and narrower. This difference is not constant even in adult specimens. In both male and female the lobe at the infero-proximal angle of the merus of the large cheliped is not covered when the carpus is bent at right angles to the merus. Ambulatory legs very similar to those in *californiensis* except the first which has the hand with lower margin very convex but becoming slightly concave near



Fig. 6. *Callianassa gigas* Dana, male, dorsal. $\times 1$.



Fig. 7. *Callinassa gigas* Dana, male, ventral. $\times 1$.



Fig. 8. *Callianassa gigas* Dana, female, dorsal. $\times 1$.



Fig. 9. *Callinassa gigas* Dana, female, ventral. $\times 1$.

the tip of pollex, the pollex about one and a half to two times as broad at base as the dactyl. Telson and uropods much as in *californiensis*.

Dimensions. Of type: length 114 mm.

Color. Usually white to cream; body may be pinkish orange to pink or orange or white; chelipeds white; leaf-like pleopods may be orange.

Type locality. Puget Sound.

Distribution. From Vancouver Island, British Columbia (Bate); to San Quentin Bay, Lower California (Lockington); Puget Sound (Dana, Calman); Gulf of the Farallones, California, 39 meters ("Albatross" station 3150), one fragmentary specimen showing the large cheliped and portion of abdomen (Rathbun). G. E. MacGinitie has reported to the author one male and one female from Elkhorn Slough, Monterey Bay, California.

Specimens have been examined by the author from the following locations: *British Columbia*: Boundary Bay (in the collection at the University of British Columbia); *Washington*: Fossil Bay, Sucia Island; Brown Island; beach at Jensen's shipyard southeast of Friday Harbor, False Bay, San Juan Island; Poulsbo; Allyn (about 150 meters south of wharf).

Remarks. Puget Sound has been cited by preceding writers as the type locality for *Callianassa gigas* Dana. At the close of the second summer's collection after having examined hundreds of *Callianassa* from various locations along Puget Sound, no specimen could be assigned definitely to *gigas*. According to Schmitt (Univ. of Calif. Publ. in Zool. 23:117-119, 1921) *Callianassa longimana* Stimpson has the "median tooth of front small and subacute" while *gigas* has the "front with a sharp median tooth." This character of *gigas* appears in the drawing of the whole animal by Dana (Crustacea, U.S. Expl. Exped. pt. 1, pl. 32, figs. 3, 3c, 1852) but in the description Dana (Proc. Acad. Nat. Sci. Phila. 6:19, 1852) gives it "*Frons paulo triangulatus*" (Front somewhat triangular). In other respects the two species are described by all writers concerned as similar except in the relative proportions of the carpus of the large cheliped which has proved to be an exceedingly variable characteristic. Accordingly a large series containing many variations was assigned to *longimana* and representatives sent to Dr. Waldo L. Schmitt of the Smithsonian Institution, U.S. National Museum, who verified the determination. However, as the series was enlarged and data accumulated it became apparent that the two species merge into one another and are in reality identical.

Following are the results of investigation of the literature concerned and also of correspondence in an effort to locate specimens which the earlier workers had designated as *gigas*. Dana's figure of the whole animal shows the large cheliped turned so that the merus is "broadest at the distal end." This is a characteristic of *gigas* according to Kingsley ("Key to the Astracoid and Thallinoid Crustacea of the U.S.," Amer. Nat. 33:823-824, figs. 2, 3, 1899). In a more detailed drawing by Dana (fig. 3c) the merus is somewhat "tapering towards the distal extremity," which is a characteristic of *longimana* according to Kingsley. The tooth at the base of the merus of Dana's figure of *gigas* is small but that is usual in females and in young males. Dana does not state whether the specimen figured is male or female and nothing is stated as to the magnification of the drawing. Dr. J. S. Kingsley of the University of Illinois was consulted with regard to the diagnostic characteristics concerned in his key and he offered no objection to proposed changes in classification. The figure in Stimpson (Jour. Boston Soc. Nat. Hist. 6:489, pl. 21, fig. 3, 1857) appears to be an exact reproduction of the large cheliped from the drawing of the whole animal by Dana, and the one by Kingsley to be the same drawing reduced. Kingsley states "merus long, broadest at the distal end;" Dana says of the distal end of the merus "*sed vix latiore*" (but scarcely broader). Holmes (Occas. Papers Calif. Acad. Sci. 7:162, 1900) and succeeding writers omit this point entirely but the confusion in interpretation of the description still exists. Dr. J. S. Holmes of the University of California has written that so far as he can discover there are no specimens of *gigas* in the collection there and adds that in his synopsis he simply transcribed Dana's description. H. A. Pilsbury, curator at Phila. Acad. Nat. Sci., states that the type specimen of *gigas* is probably no longer extant. The only other reference not cited in the synonymy for this species from this part of the world is Calman ("On a Collection of Crustacea from Puget Sound," Ann. N.Y. Acad. Sci. 11(13):260, 1898) in which he merely lists it. At Dr. Schmitt's suggestion an inquiry was sent to Dr. W. T. Calman of the British Museum of Natural History who arranged with Professor A. D. Peacock of the Museum at University College, Dundee, for the loan of a specimen labeled "*C. gigas*, Puget Sound." This specimen was collected by Dr. Calman about 30 years ago. This specimen is a female practically identical with one of the large *longimana* in the present collection. Dr. Schmitt states that the identification of the specimen labeled *gigas* at the U.S. National Museum is doubtful. This specimen is a badly damaged female of which the frontal margin is lacking. Consequently the

identification by Dr. Mary J. Rathbun of the U.S. National Museum was necessarily made on the basis of the chelipeds, there being no other characteristic parts present.

As a result of the investigation summarized above it seems that either *gigas* has not been taken since Dana's specimen or that the species *gigas* and *longimana* are virtually one. In the light of the evidence presented, the latter, in the opinion of the writer, is the more logical conclusion. The confusion existing in classification may very easily have arisen and persisted in the literature thru not having sufficiently large series of specimens, probably due to the difficulty in collecting. It seems possible that the younger males were formerly assigned to *gigas*, the older males to *longimana*, and the females to either species. The fact that in the adult females the large chelipeds are quite different from those in the adult males but similar to those in the young males may have added to the general difficulty. The various *longimana* reported are probably just mature *gigas*. There is nothing in the original description of *gigas* to exclude *longimana* from that species except the relative proportions of the carpus of the large cheliped which is found to be a variable characteristic. In both species the proportions are fairly constant in the females and in the young males, but in the older males there are decided variations which do not appear even in the medium sized specimens. It is now proposed that *Callianassa longimana* Stimpson revert to the older species, *Callianassa gigas* Dana. The definition of *gigas* is accordingly amended.

Callianassa californiensis Dana. Figs. 10-13, 16-17, 55-71.

Callianassa californiensis Dana, Proc. Acad. Nat. Sci. Phila. 7:175, 1854; Stimpson, Jour. Boston Soc. Nat. Hist. 6:489, pl. 21, fig. 4, 1857; Milne-Edwards, A., Nouv. Archiv. Hist. Nat. Paris 6:82, 1870; Lockington, Ann. Nat. Hist. (5) 2:301, 1878; Holmes, Occas. Papers Calif. Acad. Sci. 7:159, pl. 2, fig. 27, 1900; Rathbun, H. A. E. 10:154, 1904; Hilton, Jour. Ent. Zool. Pomona Coll. 8:63, 1916; Schmitt, Univ. of Calif. Pub. in Zool. 23:117, fig. 78, 1921. *Callianassa occidentalis* Stimpson, Proc. Calif. Acad. Sci. 1:88, 1856.

Characters. Median tooth of front very short and rounded, with a small triangular tooth on either side between bases of ocular peduncles and antennae. Eye-stalks variable, reaching a little beyond the end of the first antennular segment, about twice as long as wide, sides usually subparallel for less than half the length, beyond which the outer margin continues on a fairly even curve to the tip; inner margins approximated the entire length or from the base to about two-thirds the length, at which point they diverge more or less abruptly, either continuing in a straight line or incurving to



Fig. 10. *Callinassa californiensis* Dana, male, dorsal. $\times 1$.



Fig. 11. *Callianassa californiensis* Dana, male, ventral. $\times 1$.



Fig. 12. *Callianassa californiensis* Dana, female, dorsal. $\times 1$.



Fig. 13. *Callianassa californiensis* Dana, female, ventral, with eggs. $\times 1$.

form a prominent angle; tips acute, may be upturned; pigmented cornea at about the middle of the stalk. Antennule about one-third the length of the antenna, flagella subequal. Antennae from one-half to two-thirds the length of body, peduncle nearly equal in length to that of the antennules. Chelipeds in adult male very unequal, either the right or the left enormously developed; inner and outer surfaces smooth and glossy, margins more or less ciliate and minutely serrulate or denticulate except the upper margin of the ischium. Large cheliped (adult male) with ischium slender, compressed, incurved, distally widened, and finely denticulate on acute,

lower margin; merus about as long as ischium (generally a little longer) but stout, curved, almost naked except on ciliate margins, furnished with a very prominent lobe at its infero-proximal angle; carpus usually a little longer than broad, a little longer than merus, considerably longer than palm, outer surface evenly convex, margins subparallel, acute and ciliate, upper margin produced into a thin expansion overhanging the smooth inner surface, lower margin similar but not nearly so strongly produced, posterior margin below the articulation of merus produced backwards into a prominent, broadly and evenly rounded lobe; hand narrower than and about the same length as carpus (usually a little longer), convex above; palm broader than long, broadest at base, with the ciliate margins more or less incurved toward the proximal end, upper margin serrulate only at distal end; fingers with a prominent hiatus between them; a prominent upturned tooth with a serrulate margin between bases of fingers; fingers a little longer than palm and furnished with tufts of hair; pollex evenly curved upward, denticulate on upper margin; dactyl slightly longer than pollex, bent abruptly near the tip, forming a sharp hook, lower margin minutely denticulate, upper margin more or less denticulate. In the small cheliped (adult male) the margins are almost entirely smooth; the ischium resembles that of the larger one but is scarcely if at all denticulate below; merus widest near middle, shorter than ischium, without basal lobe but having an obsolescent tooth near middle of lower margin; carpus very long and narrow, with both surfaces convex, margins parallel; hand of same width as carpus and of about same length; palm longer than wide, margins parallel; fingers ciliate but not gaping, longer than pollex and not hooked at tip. Small cheliped in female is like that of male but larger cheliped is relatively smaller and of a different form; the ischium is like that of the male and the merus quite similar but furnished with a somewhat less prominent inferior lobe; carpus is similar in shape to that of male but both surfaces are convex, margins not produced as in the male; hand as wide as carpus, palm about as broad as long with margins subparallel; fingers similar to male but a little shorter than palm. In both male and female the lobe at infero-proximal angle of merus of the large cheliped is almost completely covered when the carpus is bent at right angles to the merus. Ambulatory legs stout and more or less ciliate, particularly on hands; first, second and third pairs of ambulatory legs decidedly compressed, fourth but little compressed; first, second and fourth subequal in length, the third somewhat longer; first pair considerably longer than the carapace, with short broad hand, inner and outer surfaces with tufts of hair, margins

ciliate, fingers longer than palm, pollex and dactyl subequal at base or pollex slightly broader; lower margin of merus and upper and distal portions of lower margins of carpus ciliate; second pair with hand developed into a broad blade with a small dactyl; fourth and fifth with hand longer than broad. Telson slightly shorter than uropods and furnished with a rounded emargination at tip. Uropods distally truncate and slightly exceeding the telson.

Dimensions. Length of male specimen 61 mm, length of larger cheliped 50 mm, of smaller cheliped 32 mm; length of larger cheliped of female 31 mm, of smaller cheliped 28 mm (Holmes).

Color. In younger specimens the body is usually a delicate orange to deep rose-pink, the chelipeds and ambulatory legs are rose-pink, but sometimes the whole is quite a bright orange. In adult specimens the abdomen and ambulatory legs are lighter and the chelipeds are white.

Type Locality. "California."

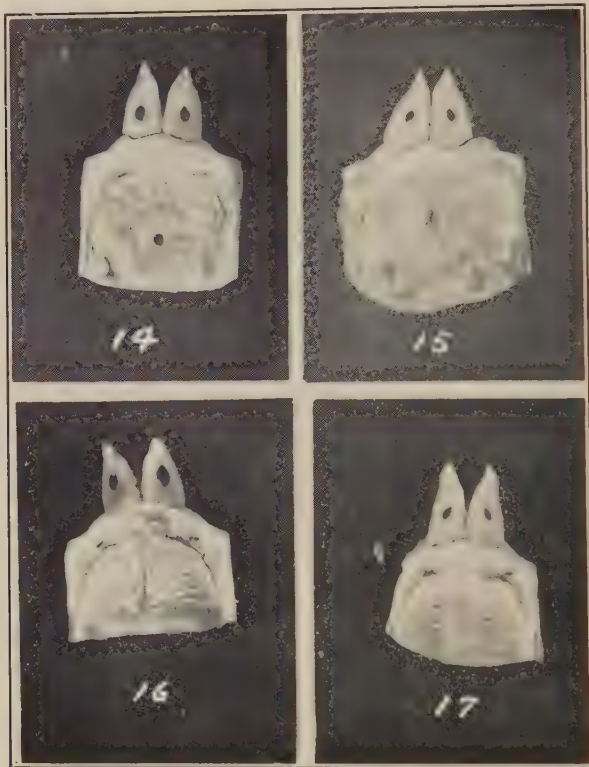
Distribution. From Mutiny Bay, Alaska (Lockington), to mouth of Tia Juana River, San Diego County, California (Rathbun).

Specimens have been examined by the author from the following locations: *British Columbia*: Locke Bay; Robert's Bay near Sidney, Tofino Inlet, Vancouver Island (in the collection at the University of British Columbia); *Washington*: beach at Jensen's shipyard southeast of Friday Harbor; Fox Cove, Sucia Island; Mabano and beach directly across on Camano Island; Sandy Point and Langley on Whidby Island; Allyn (about $\frac{3}{4}$ mile north of wharf); Seabeck and Union City on Hood Canal; Copalis; North Cove; *Oregon*: Coos Bay; *California*: Elk Horn Slough, Monterey Bay.

Remarks. The divergence of the eye-stalks has previously been indicated as a diagnostic characteristic in differentiating *californiensis* from *gigas* but in *californiensis* it is too variable to be considered as such. This is particularly true of specimens from Allyn, Seabeck and Camano Island, Washington. In these specimens the chelipeds are slightly more slender than is usual but otherwise they possess very decided *californiensis* characteristics. The degree of convexity of the median tooth of the front has also been used in separating these two species but the difference as shown in figs. 14-17 is too nearly imperceptible to be of any use in distinguishing them.

The large cheliped of *californiensis* in the male, up to about three-fourths grown, is very similar in form to that of the female, scarcely exhibiting the thin expansions of the margins of the carpus so very characteristic in the adult male.

In San Juan Islands the only locations where *californiensis* was taken are across from Fossil Bay, Sucia Island, where they are very numerous, and at Newhall's Beach where only one specimen, a male, was taken. Many *gigas* were collected at various times at Newhall's



Rostrum and eye-stalks of *Callianassa*.

Fig. 14. *C. gigas*, male. $\times 3$.

Fig. 15. *C. gigas*, female. $\times 3$.

Fig. 16. *C. californiensis*, male. $\times 3$.

Fig. 17. *C. californiensis*, female. $\times 3$.

Beach but this particular individual is unquestionably *californiensis*. By no means were all the beaches of the region visited but considerable territory is represented in the collection.

Only one case of obvious regeneration has been found in all the specimens of *Upogebia* and *Callianassa* examined. This is in a small male of *californiensis* in which the small cheliped is smaller than the ambulatory legs, very feeble and malformed.

Callianassa affinis Holmes. Fig. 18.

Callianassa affinis Holmes, Occas. Papers Calif. Acad. Sci. 7:162, pl. 2, figs. 29-30, 1900; Rathbun, H. A. E. 10:154, 1904; Schmitt, Univ. of Calif. Publ. in Zool. 23:119, fig. 81, 1921.

Characters. Front obscurely tridentate. Eye-stalks oblong, subacute, with inner extremities tuberculiform and not diverging toward the tip; cornea in front of the middle of the stalk. Antennule a little less than half as long as the antenna, flagella subequal. Antennae about half the length of the body, the peduncle nearly equal in length to that of the antennules. Eye-stalks reaching nearly to the end of the first antennular segment, little longer than wide, sides subparallel, inner extremities tuberculiform, not diverging towards the tip, pigmented cornea considerably in front of middle of stalk. Chelipeds in adult male very unequal. Large cheliped with ischium dentate below; merus stout, lower margin denticulate and furnished with a prominent lobe on the under side near the base; carpus very little longer than broad, and very little longer, sometimes even shorter,

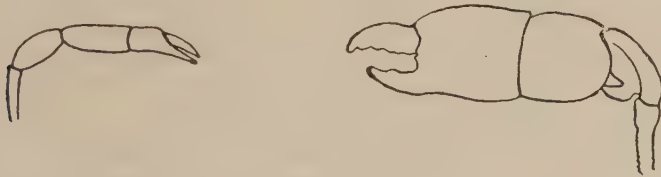


Fig. 18. *Callianassa affinis* Holmes, male; left, small cheliped; right, large cheliped. (After Holmes).

than palm, postero-inferior angle broadly rounded and the margin not produced as it is in *californiensis*; hand fully twice the length of the carpus; palm oblong, both inner and outer surfaces convex; dactyl longer than pollex, the extremity hooked and the prehensile margin furnished with a few stout teeth. Small cheliped slender; merus widest at the middle; carpus narrow, as long as the hand; fingers pubescent. First pair of ambulatory legs ciliate below. Telson broadly rounded and shorter than uropods.

Dimensions. Of a male specimen from Point Loma, in the collection of the National Museum: length from tip of rostrum to end of telson 61 mm, of carapace 17 mm, of large cheliped 50 mm, of hand and fingers 16 mm, of carpus 8.5 mm, greatest width of hand 8 mm, and of carpus 9.5 mm (Schmitt).

Color. The author finds no record of color and has not examined live specimens.

Type locality. Point Loma, California.

Distribution. From Santa Monica Bay to San Diego, California (Rathbun).

Remarks. The above description is almost entirely adapted from preceding writers since the author has examined but six specimens, loaned by the Smithsonian Institution. Of these one male and one female were collected at Isthmus Harbor, Santa Catalina Island, California; three males and one female were collected between Government Breakwater and Point Fermin, San Pedro, California.

Callianassa goniophthalma Rathbun. Fig. 19.

Callianassa goniophthalma Rathbun, Proc. U.S. Nat. Mus. 24:886, 1902; H. A. E. 10:154, pl. 8, 1904; Schmitt, Univ. of Calif. Pub. in Zool. 23:121, fig. 82, 1921.

Characters. Median tooth of front sharp and prominent, reaches barely one-third the length of the eye-stalks, lateral teeth shallow and blunt. No median carina, but a slight blunt elevation near posterior margin corresponding to the strong tooth of *C. coecigena*. Eye-stalks reaching nearly to the end of the first antennular segment, more than twice as long as wide, sides subparallel, antero-external angle rounded, antero-internal angle produced in a tuberculiform tooth, these teeth being slightly divergent, eyes without pigment. Antennule with flagella subequal. Antennae with flagella nearly as long as the body, peduncle overreaching the antennular peduncle by the length of the last and one-third of the preceding segment. Chelipeds very unequal. Large cheliped equal in length to the carpus and the first four abdominal somites combined; ischium with a few minute spinules at proximal end of lower edge; merus may have a small spine at the proximal end of its lower margin, or it may (as in the largest specimen) be devoid of armature; carpus shorter than wide, nearly twice as deep as it is long and half as long as the palm, lower angle rounded; palm a little longer than high, subequal in length to dactyl, distal lower quarter with a few tubercles irregularly disposed from which proceed bunches of hair; fingers gape widely in male, not at all in female, in both beset with bunches of long hair; pollex with a stout tooth on upper edge; dactyl longer than pollex, upper surface very broad and with a rounded carina on inside and outside, outer surface tuberculate near base of finger, outer margin of cutting surface has a broad tuberculate tooth near palm and a lobe near tip; inner margin of cutting surface is tuberculate along its distal half; lower margin of ischium, merus and carpus and both upper and lower margins of hand are carinate. Small cheliped one-third as wide as the larger, reaches only to distal third of palm of larger; ischium



Fig. 19. *Callianassa goniophthalma* Rathbun, male, about natural size (After Rathbun).

and merus similar to those of the large cheliped; carpus longer than high, low angle subacute; palm a little shorter than carpus, longer than wide; fingers do not gape as they overlap far from the extremities; dactyl slender, nearly twice as long as palm and longer than pollex which is armed with a single sharp tooth at its proximal third. First, second and third pairs of ambulatory legs stout, compressed and increasing slightly in length in the order named; fourth pair as long as the second; first pair a little longer than carpus and ending in a short, broad, compressed hand, the edges and outer surface of which are setose, as are also the lower border of the merus and the upper and distal borders of carpus; dactyli of remaining pairs almost hidden in setae. Telson nearly as long as sixth abdominal somite; sides subparallel, notched at anterior third; posterior angles rounded. Uropods broad and rounded, the outer much the larger.

Dimensions. Type, male: length of carpus 30.5 mm, of abdomen 67.5 mm; female: length of carapace 22.2 mm, of abdomen 52 mm.

Color. The author finds no record.

Type locality. Off Point Conception, California, 513 meters ("Albatross" Station 3198).

Distribution. Also taken by the "Albatross" in Clarence Strait, Alaska, 595 meters, and off Harris Point, San Miguel Island, California, 487-500 meters (Schmitt).

Remarks. Closely allied to *C. coecigena* Alcock and Anderson, but differs in the shorter rostrum, in the absence of spines on the second to fifth somites of the abdomen, in the squarer telson. The shape of the first pair of chelipeds is the same as in *C. coecigena*, but the carpus of the larger one is without a spine, the palm is not serrate on its lower margin; its outer surface is furnished with tubercles on the distal lower quarter, to which also the hairs are restricted; pollex is shorter in our species and its tooth is nearer the middle (Rathbun).

The above description is adapted from preceding writers since the author has examined but three specimens of this species, loaned by the Smithsonian Institution. Of these two males and one female were collected in the vicinity of Funtar Bay, Lynn Canal, Alaska, 549-573 meters "Albatross" Station 4258.

ECOLOGICAL OBSERVATIONS

Upogebia pugettensis is commonly found at about mean low tide on muddy beaches free from *Zostera* where there is more or less gravel. They have, however, been brought up in the dredge from several meters; they have been found ranging upward almost to high water and they have been taken in very compact clay and gravel. Occasionally they have been observed crawling over the surface but ordinarily one might walk over an area thickly inhabited by them without suspecting their presence, except for the openings to the burrows and the mounds thrown up in the process of excavation. The openings may be confused easily with those of some of the larger clams, and the mounds with those of some of the worms, but a clam opening usually has little if any mound about it, and a worm mound has no large burrow beneath it. As the burrows of *Upogebia pugettensis* are found when the tide is out, there is usually a plug of loose gravel at the opening. This plug extends down from the top to the base of the mound, a distance of about 5 cm. Probably the finer material is washed away by the action of the water.

Considerable observation of burrows was made in connection with digging out specimens but this, except for information concerning the general trend of the subterranean passage, was very unsatisfactory. There was a great tendency for the excavation to fill up with water, and the earth to cave in, thus obscuring the course of the particular burrow in question. Flexible branches of willow were run down the passageway and helped to identify the course near the surface, but deeper, the difficulties above mentioned were again encountered. Cement was poured into a few burrows in an attempt to mark their courses in that way but it also was unsatisfactory since it was practically the same color as the earth and in addition much of it oozed out thru the spaces between the gravel before hardening. Plaster of paris served the purpose very well since it hardened quickly and was easily seen, for even tho it mixed with the sand to a slight degree it remained nearly white. The only difficulty encountered in this method was in filling the burrow rapidly enough so that the plaster of paris did not harden before reaching the surface at the other opening or openings. A very thin paste was mixed in quantities of about one quart and poured immediately. One person mixed the paste while the other poured it. At the next sufficiently low tide, the cast was dug up and examined. To avoid breaking, it was necessary to remove it in sections and then rejoin these with a little freshly mixed plaster of paris. The largest burrow (fig. 20) explored

in this way by the writer extended to a depth of about 1 meter. Needless to say, the labor involved in excavating such a cast prohibited many repetitions of the experiment.



Fig. 20. Burrow of *Upogebia pugettensis* (plaster of paris cast), $\times$ about 13.

The burrows are quite cylindrical and range in depth from several centimeters to about 1 meter. The diameter varies, of course with the size of the animal but for the most part it is from 2 to 4 cm. The burrows are nearly vertical and are in a general way Y-shaped

or U-shaped with two or more branches opening at the surface and with one or sometimes more short, blind passages extending down or to the side. Some burrows, apparently in the initial stages of construction, consist of only one nearly straight channel. The longest of this sort examined extended, for the most part straight down, to a depth of .8 meter with but one very slight extension to the side.

At regular intervals of about 15 cm, or about the full length of the animal from the tip of the telson to the tip of the chelipeds, the burrow undergoes a slight curvature. This may be accounted for by the method of excavation employed which involves a queer sort of somersault in order to reverse the position after digging. A *Upogebia* was placed in a battery jar of gravel, sand and mud from the beach and its activities observed, as described below.

The load is scooped up by the third maxillipeds which are strong and pediform. A carrier is formed by the chelipeds and the first pair of walking legs. To form the sides the chelipeds are extended straight forward, about 1 cm apart with a large load. The first pair of walking legs, with their inner margins provided with rows of long interlaced hairs reenforced by shorter ones, are turned in to form a very efficient bottom. When the load is ready, the tail is well flexed and the animal turns over on its side, at the same time moving the chelipeds and the anterior end back toward the tail. As the tips of the chelae pass the tail it begins to extend in the opposite direction. When the chelae are a little beyond the tail, the animal continues its turning on the side, at the same time extending the tail in one direction and the chelae in the opposite until it lands in a normal position fully extended and headed toward the opening. In turning, the last three pairs of legs scrape the tail, thus aiding in the somersault. The whole performance takes about 10 seconds and is very gracefully done without losing the load of loose material to be transported to the surface. Then the animal moves forward with a fair degree of rapidity. In moving forward, the animal uses the chelipeds and walking legs, the tail dragging fully extended. Backward locomotion is accomplished by the additional use of the tail which is flexed and then partly extended. The turning may account in part at least for the cylindrical form of the burrow. As a result of the pressure of the animal's body in the great many trips back and forward, the walls are smooth as if plastered.

At the surface the load is shoved off by working the chelipeds and the first pair of ambulatory legs back and forth alternately. A big load amounts to about a teaspoonful.

The second walking leg, provided with a row of several long, sharp teeth curved forward, is used very effectively as a combination brush and comb for the fore part of the body. An occasional circulation of the water is produced by the rhythmical backward and forward motion of the four leaf-like pleopods. Both pairs diverge at the same time but the inner pair start back when the outer is about half way out, and vice versa, at the rate of about once a second. This creates a circulation in the water which is very apparent out to a distance of about 2.5 cm from the body of the animal.

The observations made of *Callianassa* are more casual than those of *Upogebia*. No casts were made of *Callianassa* but, judging from observations noted while collecting specimens, the burrows are very similar to those of *Upogebia*. They are, however, constructed in more finely divided material and the mound consequently lacks the plug of gravel usually present in the opening of that of the *Upogebia*. In locomotion *Callianassa* ordinarily carries the large cheliped flexed so that it is about equal in length with the smaller, which is extended straight forward. Sometimes, however, the animal travels with this seemingly cumbersome appendage extended to full length. The pads of hair on the hands of the last two walking legs serve as brushes in cleaning the body. The animal is very agile in wielding them and can even scrub the basal joints of the same appendage. They may be used singly or together in thoroughly brushing out the gills. They may also be operated on the same or on the opposite side of the body.

To ascertain what they eat, the writer examined several *Upogebia* and *Callianassa*. Their food, so far as could be determined, consists of plant debris and a very few diatoms. The great mass of material in the digestive tract consists of fine grains of sand.

ECONOMIC RELATIONS

The *Callianassidae*, popularly known as "crawfish," "mud prawns," "ghost shrimps," or "burrowing shrimps," are reported to be a great menace to the oyster industry of the Pacific Coast. In fact, Professor Kincaid has said to the writer that, in connection with his investigation of various oyster beds, he has come to consider them the worst enemy of the native oyster, *Ostrea lurida* Carpenter. The starfish, *Pisaster ochraceus* (Brandt) and *Evasterias troschelli* (Stimpson) are well known to be very destructive to oysters. It is, however, comparatively simple to combat these since they live above ground and may easily be seen and removed. The moon snail, *Polinices lewisii* (Gould), another enemy of the oyster, living above

ground, is easily killed by crushing. But owing to the subterranean habits of the *Callianassidae* and to the methods of culture necessary for growing *O. lurida*, these "crawfish" are far more difficult to cope with than the other enemies mentioned. There is a considerable area at Oyster Bay, Rocky Bay and at Little Skookum where they do a great deal of damage. Some regions like Nahcotta on the west side of Willapa Harbor where oysters were formerly abundant are now not worth working on account of the depredations of this pest; others very suitable for oyster culture have not been developed, largely because the *Callianassidae* are present.

The destruction is really two fold: (1) the smothering of the young oysters with material thrown up in the process of excavation of the burrows, and (2) the draining of the dikes which exposes the beds to drying and is consequently fatal to both young and adults.

In the excavation of their burrows both *Callianassa* and *Upogebia* throw up small mounds of sand and debris. These mounds are about 10 to 20 cm in diameter and about 3 to 8 cm high. The size of the mound varies, of course, with the kind of material. *Callianassa* is usually found in mud and sand but can work its way thru the spaces between gravel and boulders. *Upogebia* inhabits areas made up of coarser and often more compact material. On the west side of Brown Island, *Upogebia* has been observed to be quite numerous in a bed of clay so hard that it is very difficult to penetrate it even with an ordinary shovel. However, the greatest activity is carried on in ground that is quite sandy. In loose sand the young up to a length of about 4 cm are frequently found crawling about to a depth of several centimeters with no apparent burrows, but later very definite burrows are excavated. The mounds, thrown up at the openings of the burrows, by the nature of their construction are not compact, and consequently their material is easily scattered by the action of the tides.

A natural oyster bed is fairly well protected against the *Callianassidae*. It is a matting of oyster shells, mussels, fine shells and various debris. This mat is called the cultch and may be 15 to 20 cm thick. As oysters die their shells are added to this. In the natural bed the live oysters were in the upper strata and not easily harmed. But in oystering, the cultch was in earlier times taken up and carried to the shore where the oysters were sorted out. Nothing was put back. After the removal of the cultch the "crawfish" came in and mined all thru the area. In this way they have taken practically complete possession of many acres. This condition exists in Willapa

Harbor where in some cases the mounds are so numerous that their bases overlap. The oyster spat attach to the shells of the bottom and thereby fall easy victims to the operations of this pest. They are soon buried to the depth of several centimeters and die as a result of suffocation. The adult oysters may blow the stuff out for a time, but even a thin layer creates an anaerobic condition too difficult for the spat to overcome.

The second method of destruction for which the "crawfish" are responsible is more indirect than the first but just as certain. Naturally oysters grow at about mean low tide. For convenience in culture, oystering along the Pacific Coast is done from medium down to mean low tide. Thus in order to keep the beds from being exposed during very low tides it is necessary to construct dikes. These consist of low cement or wooden walls around the beds to hold a thin layer of water over the oysters. The burrows of the Callianassidae sometimes descend to a depth of 1 meter and are Y-shaped, one channel coming to the surface inside of the dike and the other on the outside. When the tide goes out this combination acts as a very effective system of drain pipes and the oysters are exposed.

Some oyster growers have made futile efforts to protect their beds by covering them with a layer of gravel or shell before planting the oysters. This is obviously a very unsubstantial barricade against such persistent burrowers. Various oyster men have reported that it takes the "crawfish" only about 1 year to bury quite completely the gravel, shell and oysters of a newly planted area.

Basalt and broken rock would form an impassable barrier but the expense involved is prohibitive. The same is true of cement.

The native oyster, *O. lurida*, will not attach to brush as will the Japanese oyster, *O. gigas* Thunberg, and the eastern oyster, *O. virginica* Gmelin. Consequently this device, which might be used to raise the spat above the invested areas, is useless as a means of relieving the situation here.

Up to the present time, according to Professor Kincaid, the most effective defense which has been developed is a double board floor such as is used over a small area at Little Skookum on Willapa Harbor. The material of the beach is shoveled off to a depth of 10 to 12 centimeters. Over this area a board floor of rough lumber is laid, which in turn is covered by another similar floor laid at right angles to the first. Then the previously removed surface material is spread out over this. No cracks are left and the Callianassidae cannot burrow thru the boards. Boarding may make possible the use of

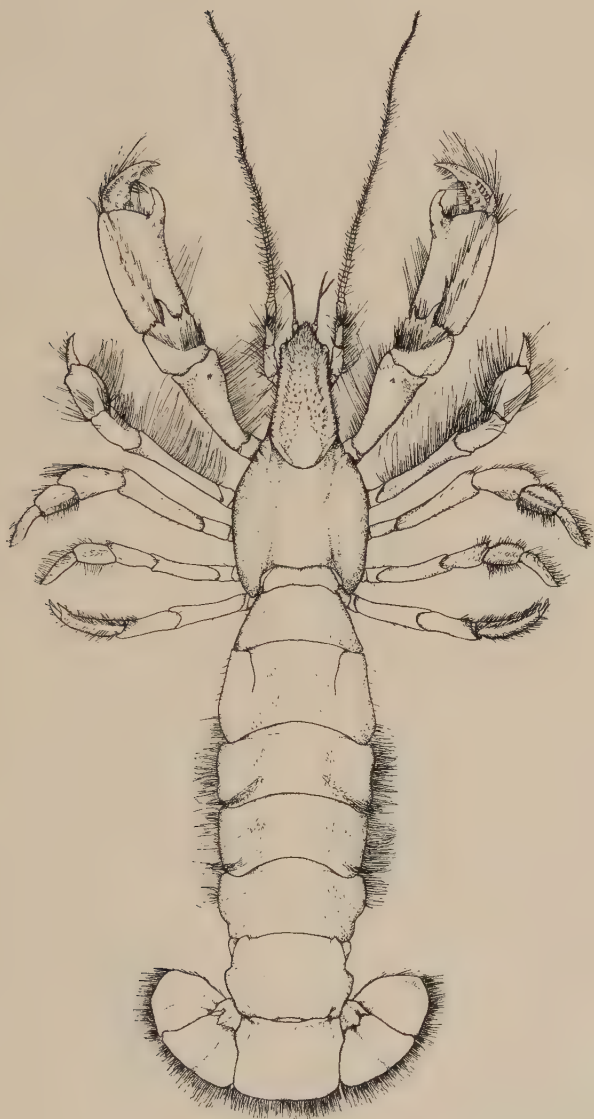


Fig. 21. *Upogebia pugettensis* (Dana), male, dorsal view. $\times 1$.

some areas not now under cultivation, but the initial expense is large and renders this plan not very practical. However, the boards are fairly permanent, since they are buried beneath several centimeters of sand and gravel and thus suffer little depreciation thru attack of wood borers.

Owing to their subterranean habits, there seems to be as yet no really adequate and at the same time economical method of coping with the Callianassidae.

Upogebia pugettensis (Dana); drawings $\times 3$.

bp - basipodite	en - endopodite	mp - meropodite
cp - carpopodite	ex - exopodite	pp - propodite
cx - coxopodite	fl - flagellum	sc - scaphognathite
dp - dactylopodite	ip - ischiopodite	

Fig. 22. Left first antenna (antennule), outer side.

Fig. 23. Left second antenna, outer side.

Fig. 24. Left mandible, ventral.

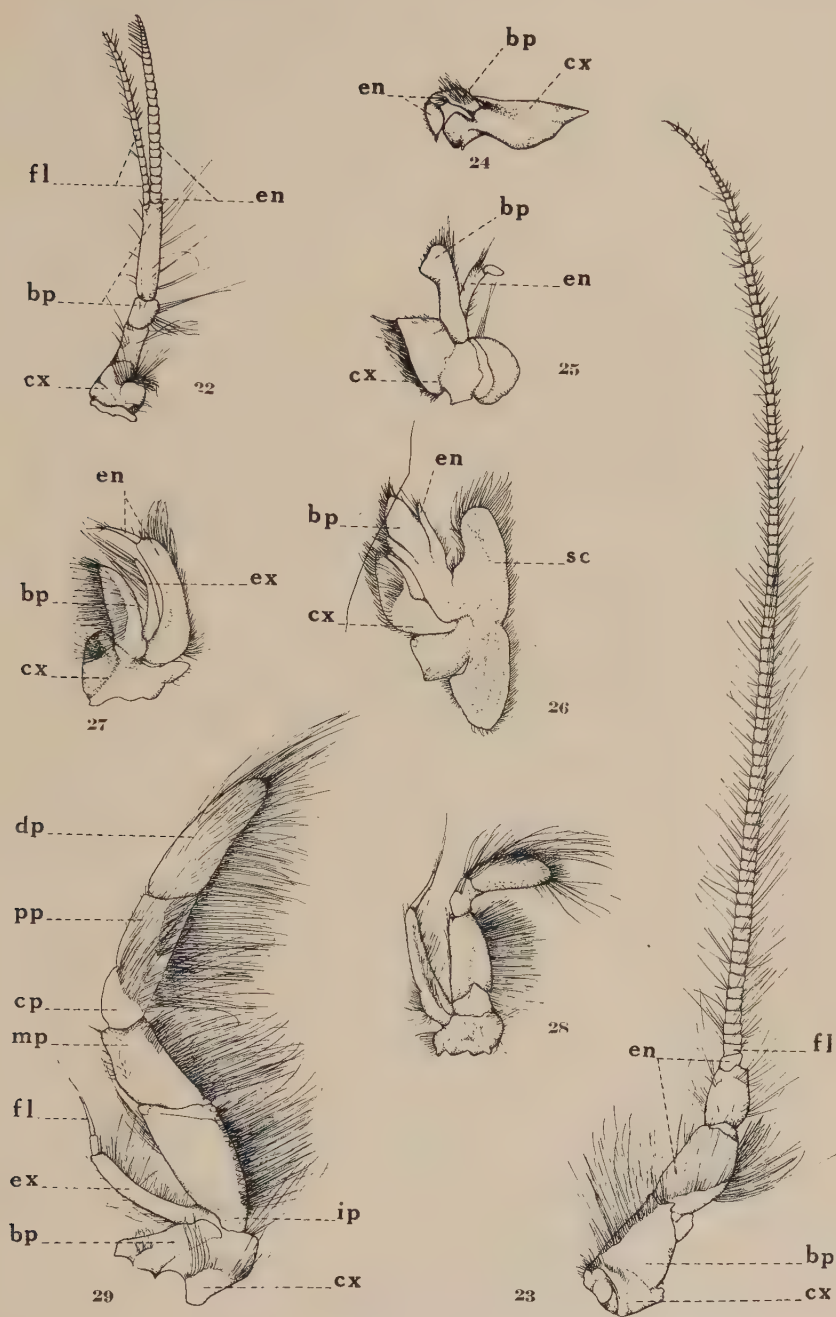
Fig. 25. Left first maxilla, ventral.

Fig. 26. Left second maxilla and scaphognathite, ventral.

Fig. 27. Left first maxilliped, ventral.

Fig. 28. Left second maxilliped, inner side.

Fig. 29. Left third maxilliped, inner side.



UPOGEBIA PUGETTENSIS

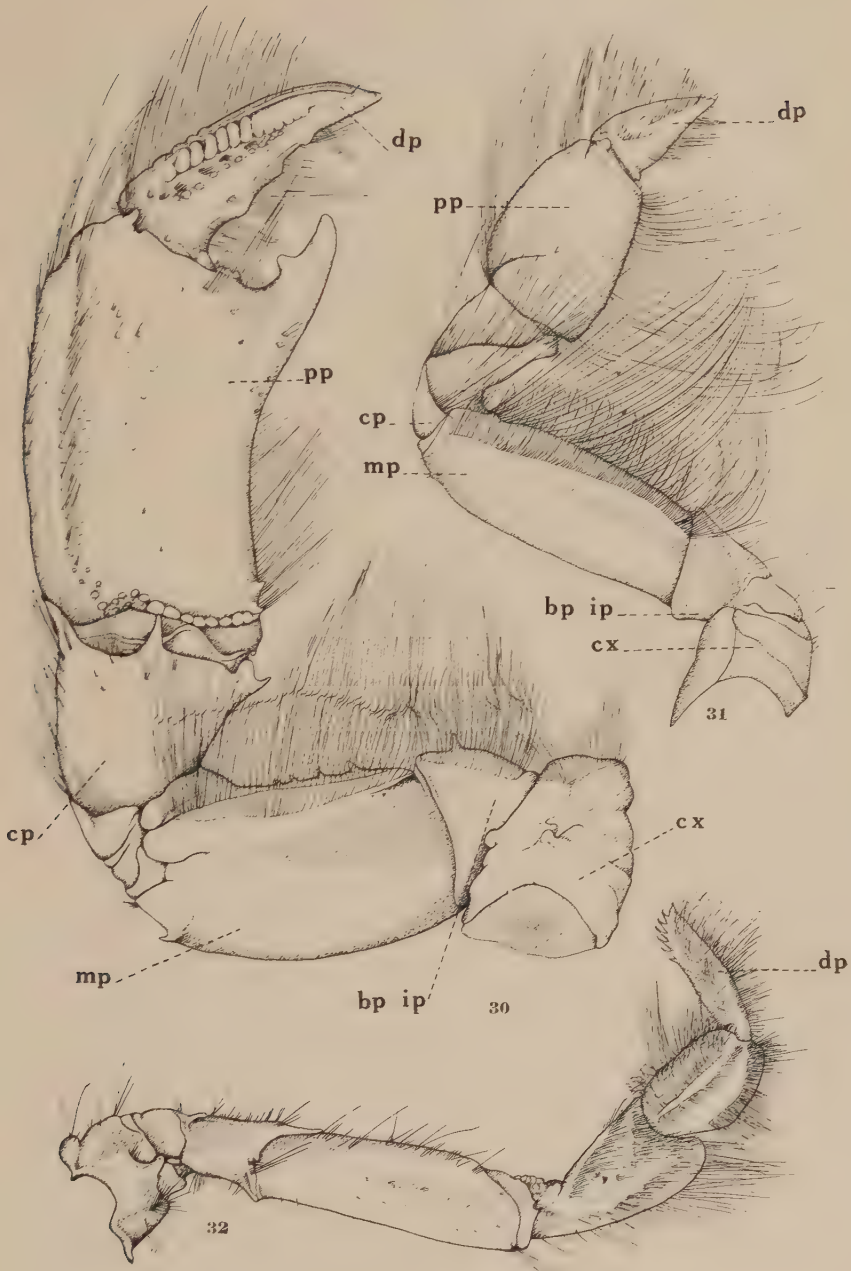
Upogebia pugettensis (Dana); drawings $\times 3$.

lp - basipodite	dp - dactylopodite	mp - meropodite
cp - carpopodite	ip - ischiopodite	pp - propodite
cx - coxopodite		

Fig. 30. Left cheliped, inner side.

Fig. 31. Left second pereopod (ambulatory leg), inner side.

Fig. 32. Left third pereopod, outer side.



UROGEBIA PUGETTENSIS

Upogebia pugettensis (Dana); drawings $\times 3$.

bp - basipodite	en - endopodite	mp - meropodite
cp - carpopodite	ex - exopodite	pp - propodite
cx - coxopodite	ip - ischiopodite	pt - protopodite
dp - dactylopodite		

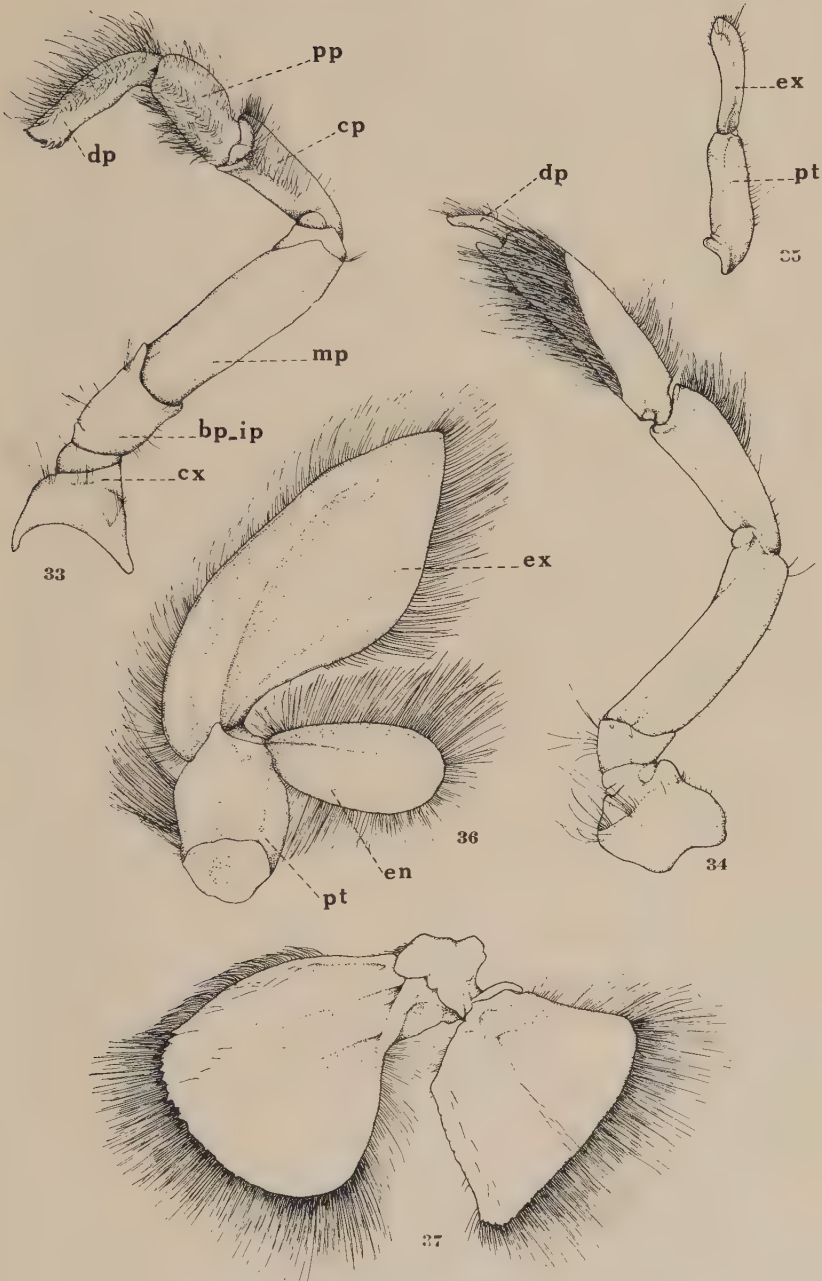
Fig. 33. Left fourth pereopod, outer side.

Fig. 34. Left fifth pereopod, outer side.

Fig. 35. Left first pleopod, female, ventral.

Fig. 36. Left first pleopod, male, (female similar), dorsal.

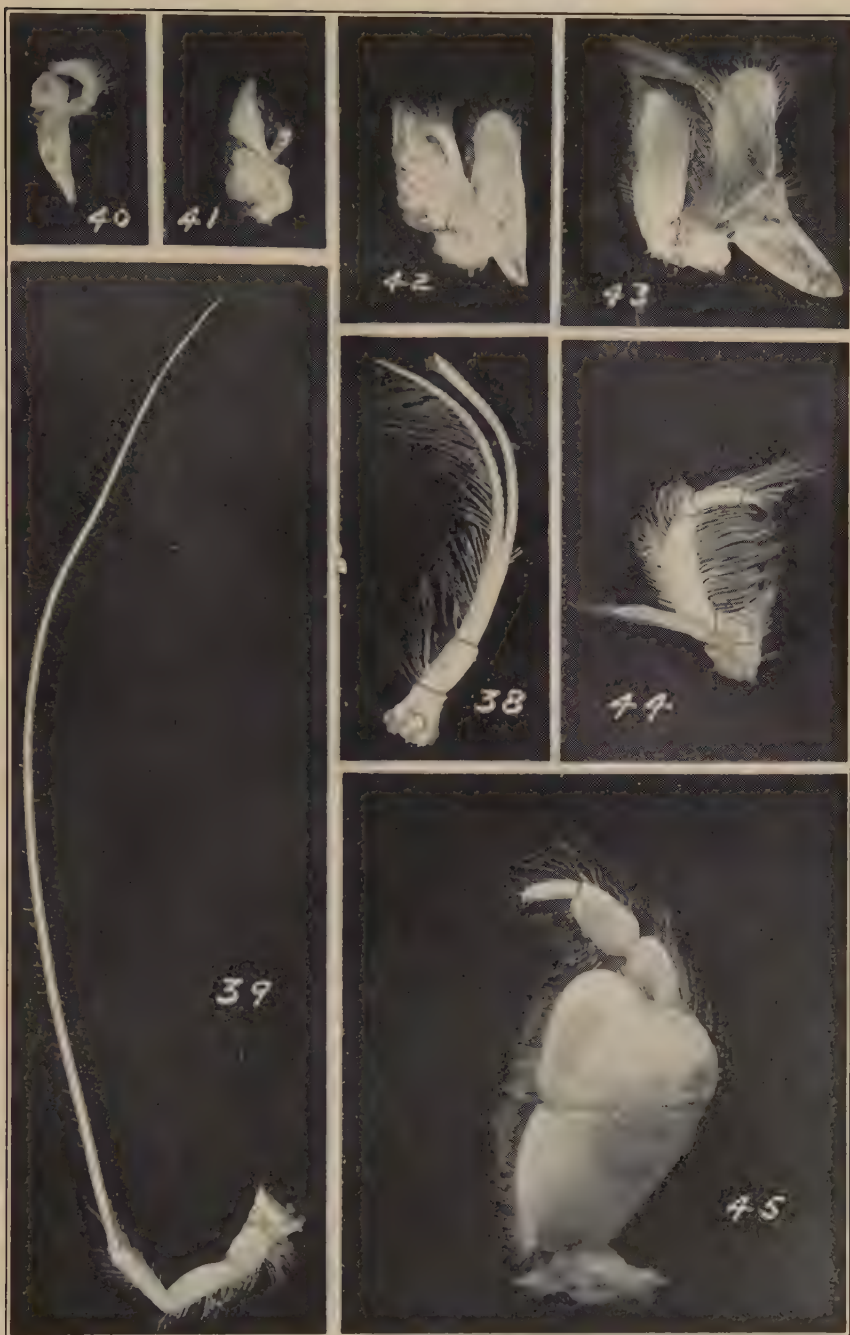
Fig. 37. Left uropod, dorsal.



UPOGEBIA PUGETTENSIS

Callinassa gigas Dana; photographs $\times 3$.

- Fig. 38. Left first antenna (antennule), outer side.
- Fig. 39. Left second antenna, lateral, outer side.
- Fig. 40. Left mandible, ventral.
- Fig. 41. Left first maxilla, ventral.
- Fig. 42. Left second maxilla and scaphognathite, ventral.
- Fig. 43. Left first maxilliped, ventral.
- Fig. 44. Left second maxilliped, inner side.
- Fig. 45. Left third maxilliped, outer side.



CALLIANASSA GIGAS

Callianassa gigas Dana; photographs $\times 3$.

- Fig. 46. Left second pereopod (ambulatory leg), outer side.
- Fig. 47. Left third pereopod, outer side.
- Fig. 48. Left fourth pereopod, outer side.
- Fig. 49. Left fifth pereopod, outer side.



CALLIANASSA GIGAS

Callianassa gigas Dana; photographs $\times 3$.

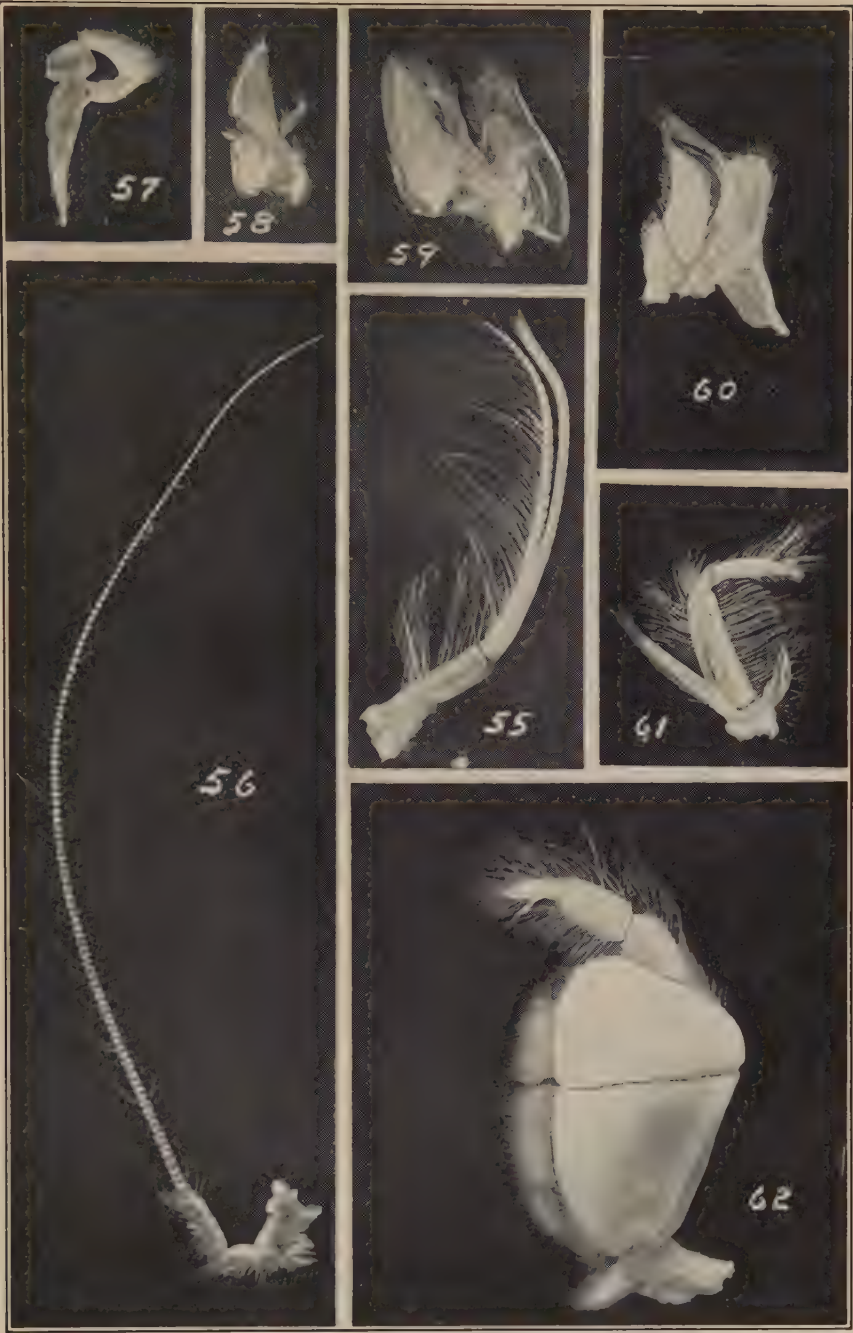
- Fig. 50. Left first pleopod, female, ventral.
- Fig. 51. Left first pleopod, male, ventral.
- Fig. 52. Left second pleopod, female, ventral.
- Fig. 53. Left third pleopod, male (female similar), ventral.
- Fig. 54. Telson and uropods, dorsal.



CALLIANASSA GIGAS

Callianassa californiensis Dana; photographs $\times 3$.

- Fig. 55. Left first antenna (antennule), outer side.
- Fig. 56. Left second antenna, outer side.
- Fig. 57. Left mandible, ventral.
- Fig. 58. Left first maxilla, ventral.
- Fig. 59. Left second maxilla and scaphognathite, ventral.
- Fig. 60. Left first maxilliped, ventral.
- Fig. 61. Left second maxilliped, inner side.
- Fig. 62. Left third maxilliped, outer side.



CALLIANASSA CALIFORNIENSIS

Callianassa californiensis Dana; photographs $\times 3$.

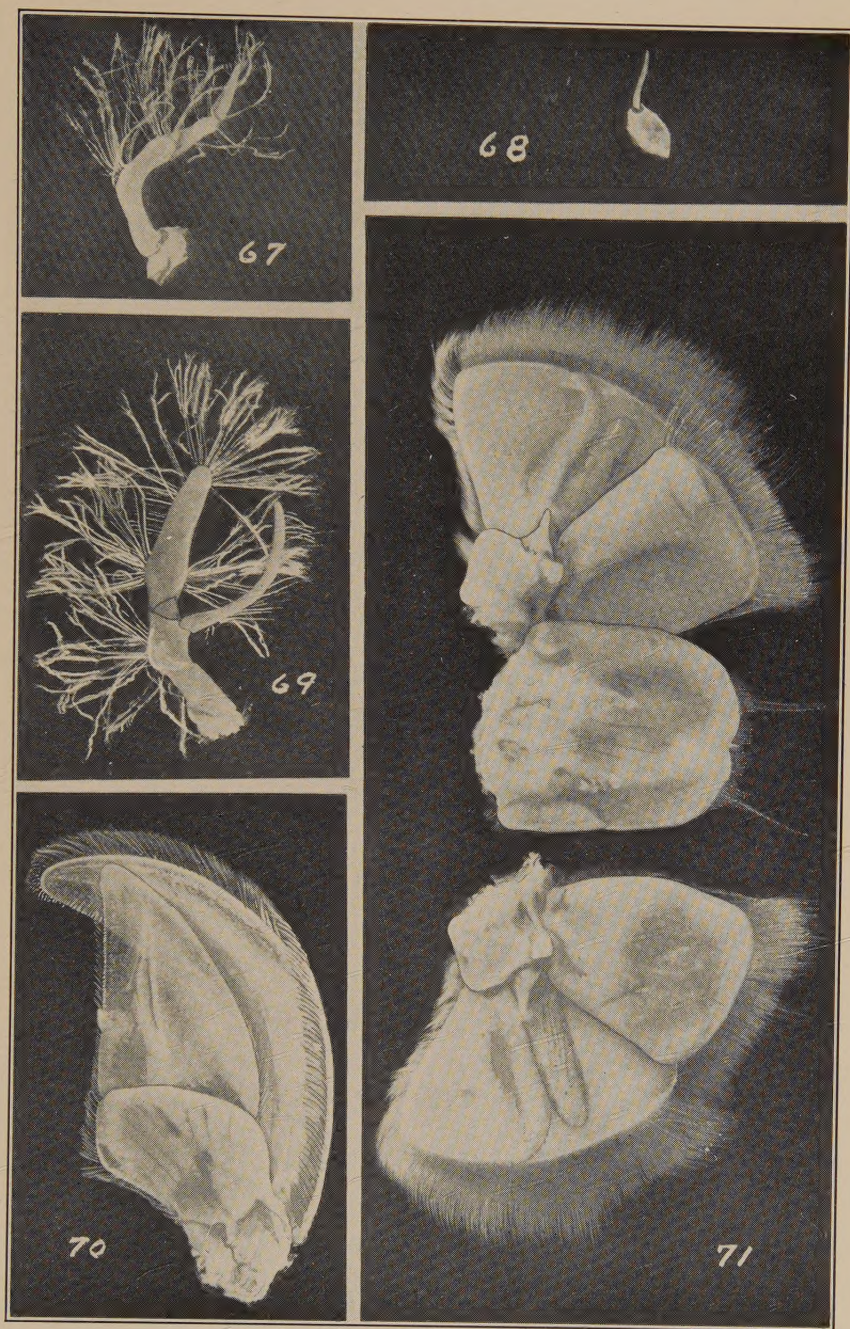
- Fig. 63. Left second pereopod (ambulatory leg), outer side.
- Fig. 64. Left third pereopod, outer side.
- Fig. 65. Left fourth pereopod, outer side.
- Fig. 66. Left fifth pereopod, outer side.



CALLIANASSA CALIFORNIENSIS

Callianassa californiensis Dana; photographs $\times 3$.

- Fig. 67. Left first pleopod, female, ventral.
- Fig. 68. Left first pleopod, male, ventral.
- Fig. 69. Left second pleopod, female, ventral.
- Fig. 70. Left third pleopod, male (female similar), ventral.
- Fig. 71. Telson and uropods, dorsal.

*CALLIANASSA CALIFORNIENSIS*

